

CLAIMS

1. A device for starting an engine, the engine including a crankshaft, an intake passage, an exhaust passage, and a plurality of cylinders having respective  
5 combustion chambers, pistons, intake valves, and exhaust valves, the device comprising:

means for setting a target amount of the reverse rotation of the crankshaft; and

10 means for rotating the crankshaft first reversely by the target amount of the reverse rotation and then rotating forwardly, to start the engine,

wherein, when the crankshaft is rotated reversely, the piston displaces upwardly while the intake valve is opened within a crank angle range corresponding  
15 to the intake stroke during the forward rotation of the crankshaft, to thereby generate a backward gas flow from the combustion chamber to the intake passage, and

wherein the target amount of the reverse rotation is set to generate the backward gas flow from  
20 the combustion chamber to the intake passage in all cylinders.

2. A device according to claim 1, wherein the target amount of the reverse rotation is set to prevent the gas having flowed backwardly to the intake passage  
25 from being discharged from an air inlet of the intake passage.

3. A device according to claim 2, wherein the intake passage which lies between the intake valve and the air inlet of the intake passage has a first volume,  
30 the exhaust passage which lies between the exhaust valve and a catalyst arranged in the exhaust passage has a second volume, and the combustion chamber and the exhaust passage which lie between the intake valve and the catalyst has a third volume, and wherein the first volume  
35 is substantially equal to or larger than the second or third volume.

4. A device according to claim 1, wherein the

engine further includes an air cleaner arranged in the intake passage, and wherein the air cleaner comprises a hydrocarbon storing agent for temporarily storing hydrocarbon therein.

5           5. A device according to claim 1, wherein the engine further includes a throttle valve arranged in the intake passage and a canister for temporarily storing hydrocarbon therein communicated with the intake passage between the throttle valve and the intake valve via a  
10           purge control valve, and wherein the throttle valve is closed and the purge control valve is opened when the crankshaft is rotated reversely, to introduce the gas having flowed backwardly into the intake passage to the canister.

15           6. A device according to claim 1, wherein the engine further includes a throttle valve arranged in the intake passage, and wherein an opening degree of the throttle valve is controlled to prevent pressure in the intake passage from exceeding a predetermined allowable  
20           value when the crankshaft is rotated reversely.

            7. A device according to claim 1, wherein the engine further includes a fuel injector for injecting fuel into the intake passage or the combustion chamber, and a spark plug, and wherein a fuel injection by the  
25           fuel injector and/or an ignition by the spark plug is conducted when the crankshaft is rotated reversely.

            8. A device according to claim 7, wherein it is determined whether the fuel injection and/or the ignition must be conducted when the crankshaft is rotated  
30           reversely, based on the warming-up condition of the engine.

            9. A device according to claim 7, wherein, if the fuel injection must be conducted when the crankshaft is rotated reversely, the fuel injection is conducted when  
35           the intake valve or the exhaust valve is opened.

            10. A device according to claim 1, further comprising means for controlling the rotational speed of

the crankshaft in the reverse direction to prevent it from exceeding a predetermined allowable speed.

11. A device according to claim 10, further comprising an electric motor for rotating the crankshaft forwardly or reversely, wherein the electric motor is controlled to prevent the rotational speed of the crankshaft in the reverse direction from exceeding the allowable speed.

12. A device according to claim 10, wherein the engine further includes a fuel injector for injecting fuel into the intake passage or the combustion chamber, and a spark plug, wherein a fuel injection by the fuel injector and/or an ignition by the spark plug is conducted when the crankshaft is rotated reversely, and wherein the fuel injection and/or the ignition is controlled to prevent the rotational speed of the crankshaft in the reverse direction from exceeding the allowable speed.

13. A device according to claim 1, wherein the cylinders have respective spark plugs, and wherein the ignition is conducted in a part of the cylinders and is prohibiting the ignition in the remaining cylinders when the crankshaft is rotated reversely.

14. A device according to claim 1, further comprising means for obtaining an engine temperature when the engine must be started, and wherein the target amount of the reverse rotation is set based on the obtained engine temperature.

15. A device according to claim 1, further comprising an exhaust throttle valve arranged in the exhaust passage, wherein the exhaust throttle valve is closed when the crankshaft is rotated reversely.

16. A device for starting an engine, the engine including a crankshaft, an intake passage, an exhaust passage, and at least one cylinder having a combustion chamber, a piston, an intake valve, and an exhaust valve, the device comprising:

means for setting a target amount of the reverse rotation of the crankshaft; and

means for rotating the crankshaft first reversely by the target amount of the reverse rotation and then rotating forwardly, to start the engine,

wherein, when the crankshaft is rotated reversely, the piston displaces downwardly while the exhaust valve is opened within a crank angle range corresponding to the exhaust stroke during the forward rotation of the crankshaft, to thereby generate a backward gas flow from the exhaust passage into the combustion chamber, and the piston displaces upwardly while the intake valve is opened within a crank angle range corresponding to the intake stroke during the forward rotation of the crankshaft, to thereby generate a backward gas flow from the combustion chamber to the intake passage, and

wherein the target amount of the reverse rotation is set to generate a backward gas flow from the exhaust passage through the combustion chamber to the intake passage in at least one cylinder.

17. A device according to claim 16, wherein the target amount of the reverse rotation is set to prevent the gas having flowed backwardly to the intake passage from being discharged from an air inlet of the intake passage.

18. A device according to claim 17, wherein the intake passage which lies between the intake valve and the air inlet of the intake passage has a first volume, the exhaust passage which lies between the exhaust valve and a catalyst arranged in the exhaust passage has a second volume, and the combustion chamber and the exhaust passage which lie between the intake valve and the catalyst has a third volume, and wherein the first volume is substantially equal to or larger than the second or third volume.

19. A device according to claim 16, wherein the

engine further includes an air cleaner arranged in the intake passage, and wherein the air cleaner comprises a hydrocarbon storing agent for temporarily storing hydrocarbon therein.

5           20. A device according to claim 16, wherein the engine further includes a throttle valve arranged in the intake passage and a canister for temporarily storing hydrocarbon therein communicated with the intake passage between the throttle valve and the intake valve via a  
10           purge control valve, and wherein the throttle valve is closed and the purge control valve is opened when the crankshaft is rotated reversely, to introduce the gas having flowed backwardly into the intake passage to the canister.

15           21. A device according to claim 16, wherein the engine further includes a throttle valve arranged in the intake passage, and wherein an opening degree of the throttle valve is controlled to prevent pressure in the intake passage from exceeding a predetermined allowable  
20           value when the crankshaft is rotated reversely.

          22. A device according to claim 16, wherein the engine further includes a fuel injector for injecting fuel into the intake passage or the combustion chamber, and a spark plug, and wherein a fuel injection by the  
25           fuel injector and/or an ignition by the spark plug is conducted when the crankshaft is rotated reversely.

          23. A device according to claim 22, wherein it is determined whether the fuel injection and/or the ignition must be conducted when the crankshaft is rotated  
30           reversely, based on the warming-up condition of the engine.

          24. A device according to claim 22, wherein, if the fuel injection must be conducted when the crankshaft is rotated reversely, the fuel injection is conducted when  
35           the intake valve or the exhaust valve is opened.

          25. A device according to claim 16, further comprising means for controlling the rotational speed of

the crankshaft in the reverse direction to prevent it from exceeding a predetermined allowable speed.

26. A device according to claim 25, further comprising an electric motor for rotating the crankshaft forwardly or reversely, wherein the electric motor is controlled to prevent the rotational speed of the crankshaft in the reverse direction from exceeding the allowable speed.

27. A device according to claim 25, wherein the engine further includes a fuel injector for injecting fuel into the intake passage or the combustion chamber, and a spark plug, wherein a fuel injection by the fuel injector and/or an ignition by the spark plug is conducted when the crankshaft is rotated reversely, and wherein the fuel injection and/or the ignition is controlled to prevent the rotational speed of the crankshaft in the reverse direction from exceeding the allowable speed.

28. A device according to claim 16, wherein the engine includes a plurality of cylinders having respective spark plugs, and wherein the ignition is conducted in a part of the cylinders and is prohibiting the ignition in the remaining cylinders when the crankshaft is rotated reversely.

29. A device according to claim 16, further comprising means for obtaining an engine temperature when the engine must be started, and wherein the target amount of the reverse rotation is set based on the obtained engine temperature.

30. A device according to claim 16, further comprising an exhaust throttle valve arranged in the exhaust passage, wherein the exhaust throttle valve is closed when the crankshaft is rotated reversely.